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(71) Applicant: **DE BEERS INDUSTRIAL DIAMOND DIVISION (PROPRIETARY) LIMITED**
8th Floor 45 Main Street
Johannesburg Transvaal (ZA)

(72) Inventor: **Sussmann, Ricardo Simon**
3 Frobisher Gardens
Guildford, Surrey (GB)

(74) Representative: **Ellis-Jones, Patrick George Armine et al**
J.A. KEMP & CO. 14 South Square Gray's Inn
London WC1R 5LX (GB)

(54) Method of bonding a diamond film to a substrate.

(57) A CVD diamond film (12) is bonded to a substrate (10) by first depositing a bonding metal (16) on a surface (14) of the substrate (10), depositing the CVD diamond film (12) on the metal layer (16) to produce a composite and heating the composite to cause the metal layer (16) to bond the CVD diamond film (12) to the substrate (10). The metal layer is preferably an alloy of copper, nickel or silver or a mixture thereof containing a carbide-forming metal.

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METHOD OF BONDING A DIAMOND FILM TO A SUBSTRATE

BACKGROUND TO THE INVENTION

This invention relates to a method of bonding a diamond or diamond-like film to a substrate.

The growth of diamond films or diamond-like films on substrates by chemical vapour deposition (CVD) methods are known in the art. These methods involve decomposing gaseous carbon compounds such as hydrocarbons or carbon monoxide in the presence of the substrate. The decomposition can be achieved using various methods including heat, radio frequency (RF) energy or microwave energy.

The diamond or diamond-like material produced by chemical vapour deposition is known as CVD diamond.

CVD diamond films deposited on a variety of substrates are finding a range of applications in areas such as cutting tools, heat sinks, wear-resistant surfaces and the like.

For many of these applications good adhesion of the CVD diamond film to the substrate is a prime consideration. However, good and reproducible adhesion has not proved to be easily achievable. This is particularly so for ceramic substrates such as silicon nitride and tungsten carbide. Delamination of the CVD diamond film occurs either spontaneously or during use.

European Patent Publication No. 0 319 926 describes a method for preparing a machining tool having a cladding layer of diamond formed by CVD techniques which comprises the steps of forming a film of diamond on a surface of a temporary substrate, bonding the diamond film by brazing to a surface of a base body of the machining tool and removing the temporary substrate.

SUMMARY OF THE INVENTION

According to the present invention, a method of producing a product comprising a diamond or diamond-like film bonded to a substrate includes the steps of providing the substrate, applying a layer of a bonding metal to a surface of the substrate, depositing a diamond or diamond-like film on the metal layer by chemical vapour deposition to produce a composite, and heating the composite to cause the metal layer to bond the film to the substrate.

DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 illustrate schematically different embodiments of the invention.

DESCRIPTION OF EMBODIMENTS

The invention utilises the ability of certain metals to wet and bond to diamond and to various substrates. The metal will vary according to the nature of the substrate. The metals which are useful in the practice of the invention can be pure metals or alloys.

Examples of suitable alloys for use with ceramic substrates are those which contain an active metal, i.e. a metal which is capable of forming a carbide. Examples of such active metals are titanium, molybdenum, hafnium, niobium, tantalum and chromium. Typically, the other metals in the alloy will be copper, gold, nickel and silver and mixtures thereof. Examples of suitable alloys are a copper/silver alloy containing an active metal and a gold/silver/tantalum/titanium alloy.

The substrate may be any known in the art, but will typically be ceramic in nature. Examples of suitable substrates are carbides such as tungsten carbide or silicon carbide, nitrides such as silicon nitride and sialon.

The heating of the composite will take place under conditions which allow bonding between the film and the substrate to take place. It is also important that the conditions are such as to inhibit degradation of the diamond or diamond-like film. Typically, the heating will take place at a temperature at or above that at which diamond growth takes place, typically of the order of 700°C to 1100°C in an inert, non-oxidising or reducing atmosphere or in a vacuum.

The diamond or diamond-like film is deposited on the metal layer by any chemical vapour deposition method known in the art. It may be deposited directly on a surface of the metal layer. Alternatively, a layer of a protective material may be sandwiched between the metal layer and the diamond or diamond-like film. The protective layer may be used to protect the metal layer from degradation during the CVD deposition and/or subsequent heat treatment.

Typically, the thickness of the CVD diamond film will be from 5 microns up to a few thousand, e.g. 3000 microns.

Embodiments of the invention will now be described. Referring first to Figure 1, there is shown a substrate 10 having CVD diamond film 12 bonded to a surface 14 thereof through a metal bonding layer 16. The metal layer 16 is deposited on the surface 14 of the substrate and the diamond film then deposited on the metal layer using any CVD method. The coated substrate is sintered in a vacuum oven at a temperature exceeding 900°C in order to bond the CVD diamond film to the substrate through the metal layer.

The CVD deposition process is carried out either in a highly reducing atmosphere containing a high

concentration of atomic hydrogen or in an oxidising atmosphere containing atomic oxygen or halogens. This environment may attack the metal bonding layer by forming hydrides, oxides or halides. To minimise this problem, a layer of a protective material may be sandwiched between the CVD diamond film and the metal bonding layer. Examples of protective materials are metals such as gold, silver and platinum and other materials such as silicon and silicon nitride. This embodiment is illustrated by Figure 2 where like parts carry like numerals. The protective material layer is numbered 18.

In place of the protective materials set out above, a layer of another protective material may be used, for example, a coating of a thin layer of amorphous or diamond-like carbon can be deposited on the metal layer 16 using any of a variety of techniques such as radio frequency plasma assisted CVD at temperatures of the order of 300°C, radio frequency (RF) sputtering, ion beam sputtering or dual beam assisted sputtering.

A combination of a first protective metal layer and a second protective material layer may also be used.

During the deposition of the CVD diamond or diamond-like film it is possible that some interdiffusion between the metal and protective layers 16, 18 could take place. To prevent this a thin layer of a "diffusion barrier" of a material such as platinum or titanium nitride may be interposed between the layers 16, 18.

Claims

1. A method of producing a product comprising a diamond or diamond-like film (12) bonded to a substrate (10) includes the steps of providing a substrate (10), applying a layer (16) of a bonding metal to a surface (14) of the substrate (10), depositing a diamond or diamond-like film (12) on the metal layer (16) by chemical vapour deposition to produce a composite, and heating the composite to cause the metal layer (16) to bond the film (12) to the substrate (10).

2. A method according to claim 1 wherein the substrate (10) is a ceramic substrate and the metal layer (16) is an alloy containing a metal capable of forming a carbide.

3. A method according to claim 2 wherein the carbide-forming metal is selected from titanium, molybdenum, hafnium, niobium, tantalum and chromium.

4. A method according to claim 3 wherein the other metal in the alloy is selected from copper, gold, nickel and silver and mixtures thereof.

5. A method according to any one of claims 2 to 4 wherein the ceramic substrate (10) is selected from carbides, nitrides and sialon.

6. A method according to any one of the preceding claims wherein a layer (18) of a protective material is deposited on the metal layer (16) prior to the deposition of the diamond or diamond-like film (12).

7. A method according to claim 6 wherein the protective material is selected from gold, silver, platinum, silicon, silicon nitride and amorphous carbon.

8. A method according to claim 6 wherein a combination of a first layer of a protective metal and a second layer of a protective material is deposited on the metal layer (16) prior to the deposition of the diamond or diamond-like film.

9. A method according to claim 6 wherein a layer of a diffusion barrier is interposed between the layer (18) of a protective material, and the metal layer (16).

10. A method according to any one of the preceding claims wherein the thickness of the diamond or diamond-like film (12) is from 5 microns up to a few thousand microns.

11. A method according to any one of the preceding claims wherein the heating takes place at a temperature of 700°C to 1100°C in an inert, non-oxidising or reducing atmosphere, or in a vacuum.

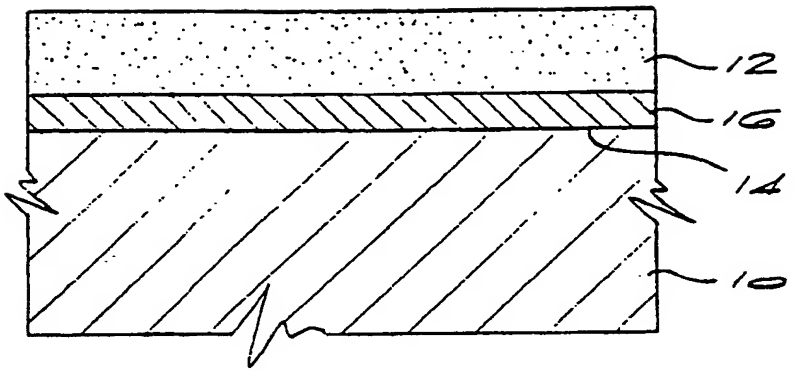

FIG. 1

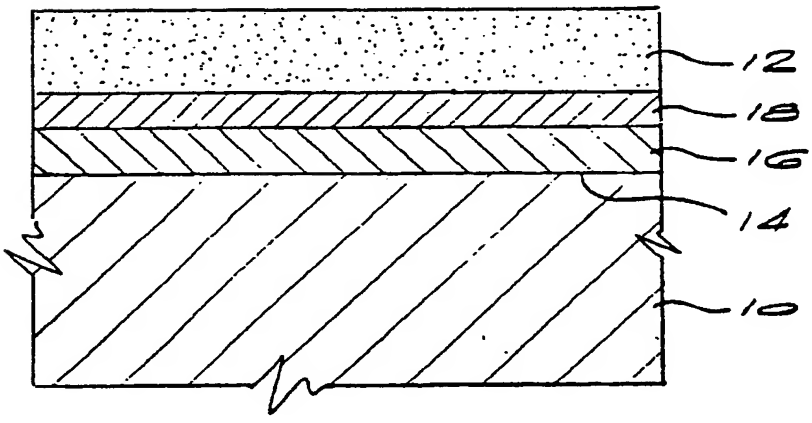

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 30 0582

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 166 708 (SANTRADE) * Page 7, example 9; claims 1,2,3,6,9,13,14 *	1-8,10	C 23 C 16/06 C 23 C 16/26 C 23 C 16/56 C 23 C 28/00
A	EP-A-0 207 467 (SHIN-ETSU DIAMOND CHEMICAL CO.) * Claim 3 *	11	
A,D	EP-A-0 319 926 (ASAHI INDUSTRIAL DIAMOND CO.)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C 23 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26-04-1991	PATTERSON A.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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